ERRATA

A PREDESIGN REPORT ON MARINE WASTE DISPOSAL

VOLUME I

CITY AND COUNTY OF SAN FRANCISCO

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The following changes are made to the text and tables of Chapter 5, Ecological Investigations, Predesign Report on Marine Waste Disposal, Volume 1.

Page 102. Change text in first column and top of second column of Biological Resource Summary to read:

A scheme of relative wildlife habitat value was developed by the San Francisco Bay Conservation and Development Commission for intertidal areas within San Francisco Bay[56]. The information presented by BCDC was extrapolated by Brown and Caldwell to include intertidal areas outside the Golden Gate as well. The extrapolation was based on policy statements by the Regional Board and on value judgments comparable to those used by BCDC. Results of the intertidal habitat valuation are presented in Fig. 5-10. The figure shows that the majority of intertidal land surrounding the City of San Francisco has a relatively fair value as a Bay wildlife habitat. Much of the ocean and Central Bay intertidal areas consist of sandy beaches which typically support a low diversity of animals. Chief inhabitants of these intertidal areas are sand burrowers (sand crabs, amphipods, clams, etc) and shore birds. Along the eastern and northeastern intertidal areas of the city, landfill and pier construction have drastically limited the availability of marine habitats for wildlife. In these areas attached organisms on pilings and rocky breakwaters constitute the major biota.

As shown in Fig. 5-10, the highest relative value of intertidal wildlife habitats in the San Francisco area is found along the east bay shoreline in the vicinity of Berkeley and south of Alameda. All of these areas are distant from any projected outfalls from the City of San Francisco. Shorelines adjacent to areas investigated in this study for possible outfall construction consist typically of sandy beaches or pier areas. These fall within the lowest classification of relative values for intertidal wildlife habitat.

Page 136. Change section In-Situ Bioassay Results to read:

In-Situ Bioassay Results. The results of the cage experiments are presented in Table 5-9. Field data are included in Volume 2, Data Supplement. As Table 5-9 shows, the results of the tests were interesting but inconclusive in determining the effect of the North Point effluent field on fish survival.

The survival of three-spined stickleback was 100 percent at the Horseshoe Bay control site in all but one test. Survivals at the other two sites varied widely from test to test. At Pier 35, where the cages were suspended in the effluent boil at effluent dilutions probably averaging about 1: 10, survival after 96 hours ranged from zero to 100 percent. At Pier 39 site, where the fish were exposed to the effluent field only half the time (on an ebbing tide) and effluent dilutions were seldom less than 1: 100, survivals ranged from 7 to 80 percent. The survival of all test animals at the Pier 39 site was only 30 percent, appreciably lower than the 49 percent measured at Pier 35. From the static bioassays of sticklebacks conducted under laboratory conditions in dilutions of composited effluent (Table 5-12) one would expect close to 100 percent survival at both Piers 35 and 39 if effluent were the only factor affecting survival. Furthermore, if effluent were the cause of low survivals in the field tests, survival should be better at the Pier 39 site than at the Pier 35 site. Limited tests at Pier 7 showed that survival was better than at Piers 35 and 39, but still lower than at the Horseshoe Bay site.

The only conclusion that can be drawn from the data is that some factor other than North Point effluent affected survival of the test fish along the San Francisco waterfront, and that this factor is missing from the Horseshoe Bay site. There was some evidence to indicate that the unidentified factor might be ship traffic. Low survivals of test fishes occurred each time a ship was docked at the pier where a cage was installed. Furthermore, the only time survival less than 100 percent was recorded at the Horseshoe Bay pier, which is normally unused, was when army reserve LST's and dredges were operating in the pier area. It would be of interest to identify the unknown factor, but positive identification would require a program of far greater scope than could be undertaken in the course of this study.

Page 136. Change Table 5-9 as follows:

Table 5-9. 96-Hour In-Situ Stickleback Bioassays

Experiment Number	Percent survival			
	Horseshoe Bay	Pier 7	Pier 35	Pier 39
1	100	--	100	[a]
2	100	--	25	20
3	100	--	0	7
4A	100	--	87	33
4B	--	--	100	80
5	100	--	27	27
6	--	[b]	100	80
7	84	68	--	--
All experiments	96	68	49	30

[a] 100 percent survival at 2 days, then cage stolen.

[b] 100 percent survival at 3 days, then cage stolen.

Page 145 through 149. Change text beginning with section Fish Bioassay Results to read:

Fish Bioassay Results. Of the many hundreds of fish obtained during the collection surveys, only seven species were collected in sufficient numbers to be used in experiments with statistically significant results. A minimum of ten fish per container was considered desirable, which with six replicates per bioassay required 60 fish for one experiment. This often meant that more than 100 fish of a single species had to be collected to allow for possible mortality through the catching, handling, transporting and acclimatizing processes.

Records for all experiments are presented in Volume 2, Data Supplement. The average percent survivals for the species studies are reported in Table 5-12. This table is the composite of 24 experiments. When sufficient test organisms were available, bioassays were conducted which studied response in all eight concentrations of composite effluent.

Shiner perch exhibited little toxicity response at dilutions greater than 1:2. Response at greater dilutions was relatively similar at all dilutions studied. The observed difference between survivals in the control and in high dilutions of wastewater were possibly the result of variability in experiments and in origin of test organisms. Percent survivals in walleye surfperch bioassay did, however, appear to reflect a slight increase in toxicity at the 1:5 dilution.

Adequate numbers of the mottled sanddab were available for bioassays in dilutions down to 1:1. Throughout the concentrations tested the mottled sanddab showed no significant effect of effluent toxicity. The average percent survival in all dilutions tested was 89. Juvenile lingcod were obtained in sufficient quantity for only one experiment with a control and two dilutions. In all of the replicates, however, survival was 100 percent at the end of 96 hours.

Enough sculpin were obtained for two experiments. Survival was 80 percent or better in all dilutions tested.

Rock bass were available in large numbers throughout most of the year. Consequently, this species was exposed to all concentrations of composite effluent. In all dilutions except pure effluent survival was 90 percent or greater. In 100 percent effluent none of the fish survived 96 hours. The high resistance of the rock bass to all but the lowest dilution was not unexpected. This species exhibits a high degree of adaptability by being distributed throughout a wide variety of habitats in San Francisco Bay and the Gulf of the Farallones. Many of these habitats are located in the vicinity of existing discharges.

Three-spined stickleback were also obtained in sufficient numbers for a complete bioassay investigation at all dilutions. This fish is normally found in the

upper estuary and has been used extensively as a standard bioassay organism. Its incorporation in this study is primarily for comparison. The results of the bioassays demonstrated that there was a high survival rate in test fish except in undiluted effluent although some small reduction in percent survival was indicated at the 1:2 and 1:1 dilutions. The stickleback survival pattern resembled closely that observed with the mottled sanddab.

The TLm and LD_{10} for the fish tested are presented in Table 5-13. The TLm is obtained from Table 5-12 by computing the percent of effluent which corresponded to 50 percent survival of the test organism. There was a significant difference in TLm for the organisms tested. The species with highest resistance (greatest tolerance) to sewage effluent were the sanddab, rock bass, and stickleback. All showed high survival at 50 percent effluent concentration. Least tolerant of those tested was the golden shiner perch, with a TLm of 20-33. This emphasizes the importance of selecting organisms from the environment that is going to receive a waste discharge if the ecological impact of that discharge is to be evaluated.

As a practical matter, a 50 percent survival of all organisms would not be considered adequate environmental protection. If instead, a 90 percent survival (LD_{10}) is arbitrarily chosen as a protection limit, a different tolerance picture is presented. Ten percent mortality would be accounted for by the response of the most susceptible individuals to any environmental change. The dilutions required to attain this survival are presented in the third column of Table 5-13. These dilutions often do not parallel the TLm because tolerance, as measured by percent survival, is not always linear with effluent concentration. For example, the effluent dilutions required to produce 50 percent survival (TLm) and 90 percent survival might be quite similar in one species and yet quite different in another.

Of all the fish studied, the sculpin and the walleye surfperch required the highest dilution (1:20-50) of municipal effluent to be assured of 90 percent survival over 96 hours. At the other extreme, the rock bass required only that the composite effluent be diluted 1:1 with background bay water for 90 percent survival. The three-spined stickleback, with the higher TLm, required dilutions of about 1:2.

Invertebrate Bioassay Results. The 96-hour static invertebrate bioassays encountered the same problem that accompanied the fish bioassays. In many species it was not possible to collect sufficient organisms for statistically significant results. Of the 19 invertebrates collected, ten were obtained in adequate numbers for analysis. The same dilutions used in the fish bioassays were investigated for invertebrates to facilitate direct comparisons. Like the fish bioassays, low effluent dilutions included salinity adjusted and salinity nonadjusted replicates. Also, when sufficient organisms for complete bioassays were not obtained, the higher dilutions were studied first. The average percent survival for the invertebrates studied is reported in Table 5-14. The results of each individual experiment can be found in Volume 2, Data Supplement.

Percent survival in two species of crabs studied, Pagurus samuelis, the hermit crab, and Hemigrapsus oregonensis, the shore crab, were quite similar. Both species exhibited a high resistance to dilutions of San Francisco sewage effluent. In all dilutions tested survival was close to 100 percent over 96 hours.

Two tests were run on the sand crab, Emerita analoga, one involving adult organisms and the other day-old larvae. The results of the adult sand crab test are open to some question because the test was run as a combined bioassay with purple sea urchins and only hard parts of the dead organisms were found. It was therefore impossible to tell whether observed mortality was due to predation or whether the organisms had died of waste toxicity before being eaten. The single 96-hour bioassay of sand crab larvae showed an apparent toxic effect of the sewage effluent in all dilutions tested. The effect was distinct at dilutions of 1: 10 and below.

Three species of shrimp studied during the static bioassay tests were the bay shrimp, Crago sp., the pink ghost shrimp, Callianassa californiensis, and the broken-back shrimp, Spirontocaris paludicola. Adult organisms were assayed in the first two species and larval shrimp in the third species. A large number of adult bay shrimp were available for testing, hence the results of these tests are considered the most definitive of the shrimp bioassays.

The bay shrimp proved difficult to handle in the laboratory, and high mortalities were often encountered in the control replicates as well as the dilution replicates. However, survival in all dilutions of 1: 50 or less was generally less than survival in the control. An obvious toxic effect was evident at dilutions of 1: 2. The limited results obtained from experiments on the other two shrimp species indicated that the reaction of all three species was generally comparable.

Survival of the turban snail, Tegula funebralis, purple sea urchin, Strongylocentrotus purpuratus, and the horse mussel, Volcella demissus, was 100 percent in all dilutions tested. Specimens of the turban snail and horse mussel were available in large numbers and most dilutions were tested. Small purple sea urchins were not obtained during the later program and therefore only high dilutions were studied. These species are all intertidal forms and would normally be subject to large variations in their environment. This natural fluctuation, and the organism's adaptation to it, may account for their high tolerance.

The bent-nosed clam, Macoma nasuta, was available for study throughout most of the laboratory program. All dilutions as well as pure effluent were eventually tested. Like most of the other invertebrates, the bent-nosed clam exhibited a high percent survival in all dilutions studied. Survival was zero in pure effluent.

Calculations of TLm and LD_{10} for the invertebrates studied are presented in Table 5-15. For the most part values for TLm could not precisely be determined.

Only in studies with the sand crab, bay shrimp, and bent-nosed clam were survivals reported that allowed for accurate TLm determination. In all other species 50 percent mortality was not encountered at any dilution tested. Of these three species, the bent-nosed clam (TLm 50) was least sensitive. The bay shrimp (TLm about 30) was less sensitive to effluent dilution than the sand crab (TLm about 6).

Determination of the dilution required to assure 90 percent survival was also imprecise in many species. In all but five species the test organism showed survivals greater than 90 percent. The sand crab, bay shrimp and pink ghost shrimp apparently require dilutions of about 100: 1 to assure 90 percent survival. Broken-back shrimp larvae require about 50: 1. At the other end of the scale, the bent-nosed clam required dilutions no greater than about 1: 1 for 90 percent survival.

Static Bioassay Summary. Composite San Francisco effluent was relatively nontoxic to all test species at dilutions greater than 1: 20. Furthermore, only in the sand crab larvae bioassays were survivals as low as 50 percent in dilutions of 1: 10. All studies indicated that no significant toxic effect from the composite effluent could be demonstrated after 96 hours exposure in dilutions greater than 1: 100.

Several limitations are inherent in the static bioassays. First, tests were only conducted for 96 hours and therefore reflect only actute toxicity. Second, the organisms tested represente only those that were widely abundant. It is possible that more sensitive species were present in the environment but were not collected. Third, the ability of some species and not others to survive the stresses of collection, handling, transportation and acclimation to new conditons may have meant that only the harder individuals were available for bioassays. In such case the test results could indicate the effluent to be less toxic than might be the true case in an environmental exposure. Finally, the experimental procedure required that organisms usually be within specified size limites (approximately $\frac{1}{2}$-inch to 6 inches) for easy analysis. This, then, would often neglect many of the smaller species or young individuals of the tested species. It is known that the young of a species are generally more susceptible to environemtnal change. Also, large fish and marine mammals could not be tested. In an attempt to resolve some of the questions left unanswered by the 96-hour static bioassays, static bioassays were conducted in an environmental chamber.

Page 146. Change Table 5-12 as follows:

Table 5-12 Percent Survival after 96 Hours

	Control (0)	1:100 (1)	1:50 (2)	1:20 (5)	1:10 (10)	1:5 (20)	1:2[s] (33)	1:2[p] (33)	1:1[s] (50)	1:1[p] (50)	1:0[s] (100)	1:0[p] (100)
Shiner perch												
Cymatogaster aggregate	79		60	80	73	73	18	23	0	0		
Walleye surf perch												
Hyperprosopon argenteum	97	100	95	83	83	67						
Mottled sand dab												
Citharichthys sordidus	100			95	84[a]	95[a]	100	100	88	88	75	
Ling cod												
Ophiodon elongatus	100	100	100									
Sculpin												
Scorpaena guttata	94	100	100	80	80	80						
Rock bass												
Sebastodes sp.	100	100	100	100	100	100	100	100	100	90	0	
Three-spined stickleback												
Gasterosteus aculeatus	90	95	90	100	100	83	87	98	70	68	3	53

Figures in parentheses are the percentage of sewage effluent

[a]One animal escaped. Survival expressed as percent of animals remaining in tank at end of test.

[s]Salinity adjusted to the level of the diluting water by addition of NaCl.

[p]Salinity not adjusted.

Page 147. Change Table 5-13 as follows:

Table 5-13. TLm and LD-10 for Static Fish Bioassays

Organism	TL_m[a], percent	Estimated minimum dilution for 90 percent survival (LD 10)
Shiner perch *Cymatogaster aggregata*	20-33	1:10-20[d]
Walleye surfperch *Hyperprosodon argenteum*	b	1:20-50
Mottled sand dab *Citharichthys sordidus*	b	1:1-2
Ling cod *Ophiodon elongatus*	b	c
Sculpin *Scorpaena guttata*	b	1:20-50
Rock bass *Sebastodes* sp.	50-100	1:1
Three-spined stickleback *Gasterosteus aculeatus*	50-100	1:2[d]

[a]Estimated values from Table 5-12.

[b]Greater than 50 percent survival in all dilutions tested.

[c]Greater than 90 percent survival in all dilutions tested.

[d]In relation to control.

Page 148. Change Table 5-14 as follows:

Table 5-14 Percent Survival after 96 Hours

Organism	Control	Dilution ratio, effluent : dilution water										
	(0)	1:100 (1)	1:50 (2)	1:20 (5)	1:10 (10)	1:5 (20)	1:2[s] (33)	1:2[p] (33)	1:1[s] (50)	1:1[p] (50)	1:0[s] (100)	1:0[p] (100)
Hermit crab												
Pagurus samuelis	96	100	95	100	75	100						
Shore crab[a]												
Hemigrapsus oregonensis	97	95	98	97	97							
Sand crab												
Emerita analoga (adult)	93[a]	76[a]	71[a]									
Emerita analoga (larvae)	82	76	59	71	35		0	0				
Bay shrimp												
Crago sp.	60	53	45	47	45	42	17	23	7	7	0	0
Pink ghost shrimp												
Callianassa californiensis	100	83	83									
Turban snail												
Tegula funebralis	100[b]	100[b]	100[b]	100	94	100						
Sea urchin												
Strongylocentrotus purpuratus	100	100	100									
Bent-nosed clam												
Macoma nasuta	100	100	100	100	100	91	91	100	100	82	0	0
Ribbed horse mussel												
Volcella demissus	100	100	100	100	100	100	100	100	100	100		
Broken-back shrimp												
Spirontocaris paludicola (larvae)	100	90	90									

Figures in parentheses are the percentage of sewage effluent.

[a]Predation a possibility.

[b]Some animals escaped. Survivals expressed as percent of animals remaining in tank at end of test.

[s]Salinity adjusted to the level of the diluting water by addition of NaCl.

[p]Salinity not adjusted.

Page 149. Change Table 5-15 as follows:

Table 5-15 TLm and LD_{10} for Static Invertebrate Bioassays

Organism	TL_m[a], percent	Estimated minimum dilution for 90 percent survival (LD-10)
Hermit crab		
Pagurus samuelis	[b]	1:10
Shore crab		
Hemigrapsis oregonensis	[b]	[c]
Sand crab		
Emerita analoga (adult)	[b]	1:100[e]
Emerita analoga (larvae)	5-10[d]	1:100[d]
Bay shrimp		
Crago sp.	20-33[d]	1:100[d]
Pink ghost shrimp		
Callianassa californiensis	[b]	1:100[e]
Broken-back shrimp (larvae)		
Spirontocaris paludicola	[b]	1:50
Turban snail		
Tegula funebralis	[b]	[c]
Purple sea urchin		
Strongylocentrotus purpuratus	[b]	[c]
Bent-nose clam		
Macoma nasuta	50-100	1:1-2
Ribbed horse mussel		
Volcella demissa	[b]	[c]

[a] Estimated values from Table 5-14.

[b] Greater than 50 percent survival in all dilutions tested.

[c] Greater than 90 percent survival in all dilutions tested.

[d] In relation to control.

[e] Test results questionable.

Page 155. Change first two paragraphs of section Environmental Chamber Summary to read:

Environmental Chamber Summary. The results of the Dungeness crab egg hatching bioassays indicated that there was significant toxic effect of composite effluent at a dilution of 1:50. Egg hatching at a dilution of 1:100, although somewhat higher, was not significantly different from that in the control.

Survival of newly-hatched and 4-day old Dungeness crab zoea was somewhat greater in dilutions greater than 1:50 than in the controls, but the results were not conclusive. More conclusive results were obtained from the sand crab larvae experiments. In these studies, survival in a dilution of 1:100 was significantly better than in the control while survival in a dilution of 1:50 was about the same as in the control. In the 20-day old Dungeness crab zoea and the bay shrimp experiments, all concentrations of effluent produced detrimental effects on survival.

Page 160. Add the following paragraph to end of first column before Summary of Results:

In apparent contradiction to the results of this biostimulation experiment, Schumann's Microcosm Study (Vol. 2, Data Supplement) describes a biostimulatory response in an aquarium containing effluent diluted 100: 1 and a lesser response in a second aquarium with a 200: 2 dilution. There is an evident need for further work in this area.

Page 164, item 17. Change last two sentences to read:

The bent-nose clam exhibited a high percent survival in all dilutions studied. Survival was zero in pure effluent.

Page 164, item 18. Change second and third sentences to read:

In all but five species the test organisms showed survivals greater than 90 percent. The sand crab, bay shrimp and pink shost shrimp apparently require dilutions of about 100: 1 to assure 90 percent survival. Broken-back shrimp larvae require about 50: 1.

Page 164, item 19. Change last sentence to read:

Furthermore, only the sand crab larvae exhibited mortalities as high as 50 percent at a dilution of 10: 1.

Page 211. Change section In-Situ Bioassays to read:

In-Situ Bioassays. An attempt was made to assess the toxic effect of the North Point effluent by suspending fish in cages in the effluent field. Test results were inconclusive in determining the effect of the effluent field on fish survival. There was some evidence that bay water along the San Francisco shoreline was more toxic than at the Horseshoe Bay control site. The source of this apparent toxicity was not identified.

Page 211. Change section Static Bioassays to read:

Static Bioassays. Static bioassay tests were used to measure toxic response of juvenile and adult fish and invertebrates to dilutions of San Francisco sewage effluents. These 96-hour tests measured acute toxicity by means of mortality in dilutions ranging from pure effluent to 1:200 effluent:seawater.

Seven species of fish and ten invertebrates were tested in static bioassays. The most sensitive fish were walleye surfperch and sculpin, which required dilutions between 1:20 and 1:50 to assure 90 percent survival for the test period. Of the invertebrates, the most sensitive species were the sand crab, bay shrimp and pink ghost shrimp, all of which required dilutions of about 1:100 to insure 90 percent survival. Results of the tests on the sand crab and pink ghost shrimp was difficult to separate from a general low tolerance to laboratory experimentation. In no case could significant toxic response be demonstrated after 96 hours exposure in dilutions greater than 1:100.

Page 211. Change section Environmental Chamber Experiments to read:

Environmental Chamber Experiments. Bioassays of small organisms, including eggs and larvae of Dungeness crab, were conducted in the rigorously controlled climatic conditions of an environmental chamber. The egg hatching studies showed a toxic effect at a dilution of 1:50 but no effect at a dilution of 1:100. Similar results were obtained in tests on larvae of Dungeness and sand crabs.